25

Recycling Used Electronics

Report on Minnesota's Demonstration Project

PLUG INTO RECYCLING

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The full report will be available on the OEA Web site in May (www.moea.state.mn.us).

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Minnesota Office of Environmental Assistance

SONY

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PLUG INTO RECYCLING

Executive Summary

In 1999, Minnesota's Office of Environmental Assistance (OEA) managed a public/private effort to learn more about the costs and barriers to recycling used electronic products. Electronics contain large amounts of identifiable contaminants. Cathode ray tubes (CRTs), the picture tubes from televisions and computer monitors, are one of the largest sources of lead in municipal waste. End-of-life (EoL) electronics also contribute a relatively large amount (roughly one percent and growing) to the volume of municipal waste, even though the residual material in these products has a relatively high value for recycling.

Through a demonstration project, the OEA worked with local communities and counties across Minnesota and with industry partners to collect and recycle used electronics. Each principal partner—Sony Electronics, Waste Management-Asset Recovery Group (WM-ARG), Panasonic, the American Plastics Council and the OEA—dedicated a minimum of $25,000 to the project.

The joint effort was designed to implement key aspects of product stewardship, a voluntary approach to managing products at end-of-life in which all parties who design, manufacture, sell, use and dispose of products are expected to share responsibility for managing that product when no one wants it anymore. Bearing some of the costs for managing products at end-of-life encourages manufacturers to design products differently, so that the products use less packaging, are easier to recycle and contain fewer toxic constituents. This project used the strengths of each of the five partners to develop the first large-scale multi-stakeholder effort in North America to divert used electronic products from municipal waste.

Amounts of Lead in CRT Glass

Pounds of lead	Size of CRT
1 pound	13-inch
1.5 pounds	17-inch
4 pounds	27-inch
6.5 pounds	32-inch

Pure lead is not found in a CRT, but 22 to 25 percent, by weight, of funnel glass is in the form of lead oxide. (Sony Electronics)

Objectives

By learning more about collection methods and about recycling markets available for secondary materials derived from EoL electronic products, the partners hoped to be able to use the findings as a basis for future policy-making and program decisions in Minnesota and for corporate decisions by the manufacturing and recycling partners.

The specific objectives of the joint effort were to:

- **Explore the economies of scale** for recycling used electronic products.
- **Evaluate "high-end" recovery of CRT glass and engineering plastics** from used electronic products along with "best economical" recycling options.
- **Evaluate costs of recycling materials** from these products by learning more about the recycling markets available for secondary materials derived from end-of-life electronics.
- **Increase electronics recycling in Minnesota** without relying solely on government.
- **Identify infrastructure development needs** by comparing and assessing costs and effectiveness of various collection techniques sponsored by local government and retailers.

Planning

The partners chose to target any electronic or electrical product with a cord or battery, expanding the collection effort to include electrical as well as electronic products. Accepting "anything with a cord or a battery" communicated a simple, clear message to the public and also made it easy to collect products with nickel-cadmium and other batteries that contain heavy metals.

The partners believed that no single collection strategy was likely to meet the diverse needs of communities and regions in Minnesota. Through a Request for Participation process, the partners sought local sponsors for a variety of collection methods. This would make it possible for the project to compare participation rates among various methods and to learn if some methods were more successful and/or less costly than others at capturing used products.

Once collection sites were selected, the OEA and WM-ARG worked with each local site host to prepare for the collection event designed for that community—establishing dates for collection events, duration of events, target audience and other relevant details.

Results

The project relied on 64 collection sites in 32 Minnesota counties, including three retail locations that volunteered to participate. From July 31 to October 31, 1999, residents in selected communities were given an opportunity to bring used electronics to collection sites.

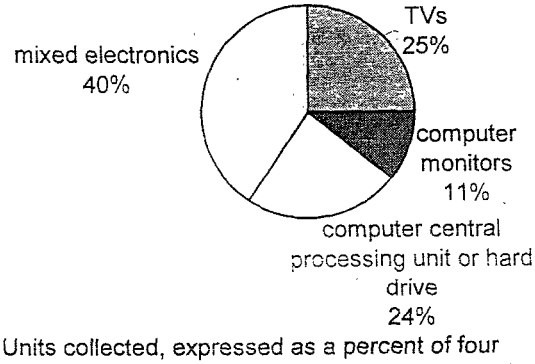
Participation

In all, 7,639 participants completed surveys when dropping off used electronics at collection events. The estimated potential population served by these events was 1.3 million[3]. According to survey results, most people participated because they liked the idea of recycling the product and they wanted to protect the environment. When participants were asked who should pay for the safe recycling and disposal of electronics, 38 percent said manufacturers, 34 percent considered it the responsibility of consumers, 15 percent said government, 6 percent said retailers and 7 percent said other.

Amount of product collected

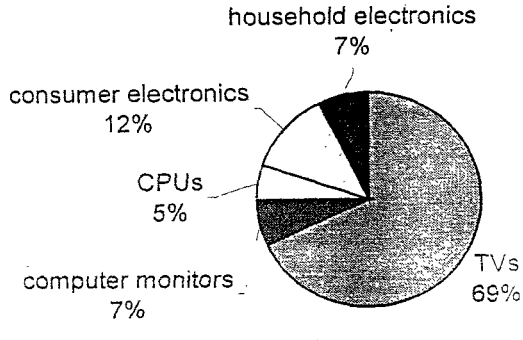
During the three-month collection phase of the project, 575 tons of used product—almost twice the amount partners expected—were dropped off at collection sites. The used product required an additional 125 tons of packaging (pallets, gaylord boxes, shrink-wrap and so forth) to ship the product from the collection sites to Waste Management-Asset Recovery Group's processing facility located in the Twin Cities metropolitan area. The products were separated into five broad categories, disassembled and evaluated for scrap content and value.

Product Categories as a Percentage of Total Number of Collected Electronics



Units collected, expressed as a percent of four broad product categories, based on responses to the participant survey. Mixed electronics includes consumer and household products.

Product Categories as a Percentage of Total Weight of Collected Electronics



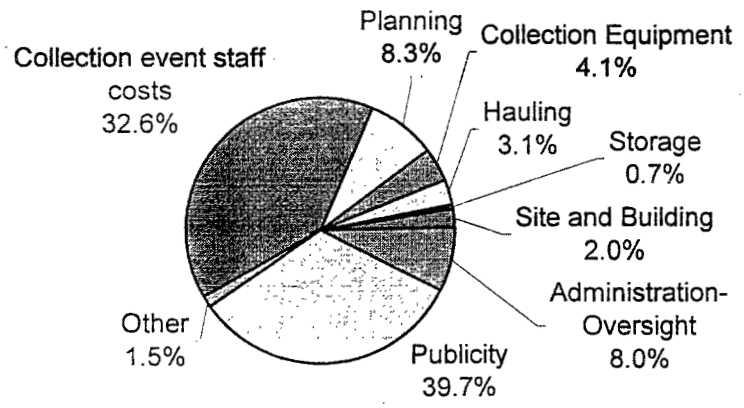
Weight of units collected, expressed as a percent of five broad product categories, reported by the recycler.

[3] It is important to note that we did not have a method to track undercounted participation. Also one could equate participants to households. Many waste and recycling programs, such as local government HHW programs, track participation by household. For this project, there was interest to identify total population served.

Costs

Local collection site sponsors reported spending a total of $165,843 to plan, prepare, administer and host collection events, an equivalent of about $288 per ton of product collected. Publicity and event staffing were the largest costs incurred by hosts of collection events. The principal partners on the project structured financing for the collection events so that local collection site hosts would not incur costs to transport old products from the point of consolidation to the processing facility, nor would they incur a charge to recycle these products. Nonetheless, the cost to collect product was significant.

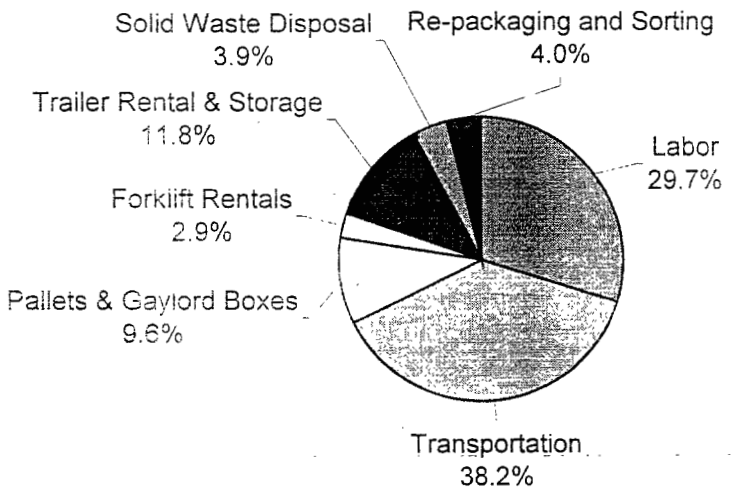
Costs to Local Collection Sites



Publicity and staffing costs made up 72% of the total costs to the collection hosts.

Transportation from collection events to WM-ARG represented 36 percent—more than a third of all costs to WM-ARG. Net processing costs, excluding transportation, equipment and storage were about $93 per ton, or $4.20 per 90-pound television. WM-ARG reported total operating costs of approximately $135,000, excluding overhead and return on investment, and revenues from recovered secondary materials of approximately $43,000. Net cost was $160 per ton to transport, process and market reusable and secondary materials.

Costs to Recycler



Glass recycling

In all, 45,000 pounds of glass were shipped to a glass recycler and 226,000 pounds of glass were shipped to a lead smelter. Inclusive of transportation, it cost $0.025 per pound to send glass to the CRT glass manufacturing sector and $0.045 per pound to send glass to lead smelters to be used as a fluxing agent and for lead recovery.

While examining the cost of glass-to-glass recycling was among the initial objectives, the option used was identified late in the project. Had this option been available earlier, more glass from the project would have been recycled in this manner.

Plastics analysis

More than 30,000 pounds of plastics were shipped to MBA Polymers, Inc. in California for evaluation and processing. The plastics analysis determined that the dominant plastic resin from televisions (FR HIPS) can meet critical specification standards and can be reused in new products. In other words, based on the properties tested, it is possible to segregate post-consumer engineering plastics and meet stringent quality requirements.

Plastics Resins Found in Sample from Collected Electronics

Plastic Resin	Television Plastics	Computer Plastics	Miscellaneous Plastics	Percent of Total Sample
HIPS	82%	25%	22%	56%
ABS	5%	39%	41%	20%
PPE	7%	17%	4%	11%
PVC	<1%	5%	15%	3%
PC/ABS	0%	6%	7%	3%
PP or PE	0%	3%	8%	2%
PC	1%	4%	1%	2%
Other	<1%	<1%	2%	<1%
Unidentified	5%	0%	0%	3%

Conclusions

Strategic voluntary partnerships can work.

The demonstration project proved worthwhile for bringing public and private interests together to work toward common goals and for revealing costs and burdens to everyone for returning used electronics to the recycling supply chain. The project established the value of future collaboration among government, recyclers and manufacturers for addressing solutions for removing used electronic products from municipal waste.

Working model of shared product responsibility.

The demonstration project proved the advantages of public/private collaboration to prevent the disposal of used electronic products in municipal waste. It provided direct ties to the marketplace at critical stages of work, as well as direct communication to regulatory authorities.

There is a high cost associated with handling used products.

Reducing the number of times products must be handled from the point of collection to the point of sale as reusable product or secondary material will reduce overall operating expenses.

Pilot costs are higher than the costs of a mature program.

As with many pilot efforts, the program costs for this first-of-a-kind demonstration project included many one-time capital and operating expenses, raising costs. Costs for collection, transportation and

handling also were higher than expected. Mature programs to recycle used electronic products may be less expensive as they develop and adopt more efficient system methods.

Adequate funding will motivate local government participation.

Well-attended public collection sites proved more costly to host and required more time to prepare and staff than anticipated. Adequate funding for future events may affect decisions by local government to host or sponsor such events. The cost to collect and transport used electronic products and related secondary commodities are key to developing a reuse and recycling infrastructure.

Collection methods.

Events that only collected electronic products were more cost-effective and attracted more participants than collection events held in association with other waste management or recycling activities. Retail, as a collection strategy for used electronic products, was the single most successful strategy employed during the project, as a percent of total participants or as a cost per participant.

Comparison of Collection Strategies

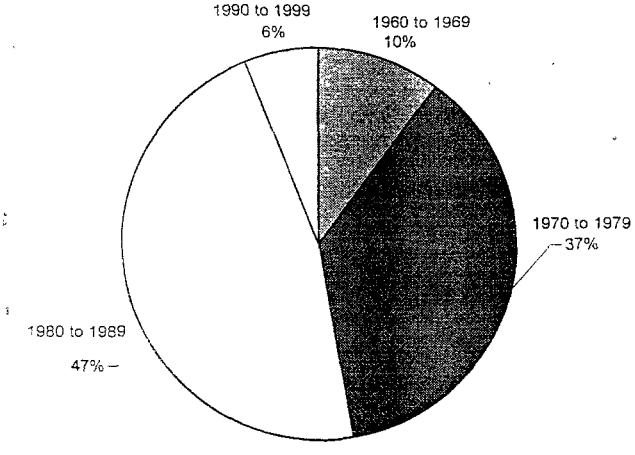
Collection Strategy	Number of Participants	Number of Sites	Average Cost Per Participant
Curbside	297	1	$19.30
Household hazardous waste sites	882	14	$69.72
Multi-facility	983	12	$68.41
Permanent Recycling Facility	440	6	$60.61
Retail	2,667	3	$11.75
Special collection, electronics only	1,536	12	$22.88
Special collection, multi-purpose	834	16	$26.42

Retail stores can provide a desirable and significant link in the process of moving used electronic products from consumers back to the recycling supply chain. The pilot showed that retail stores can add significantly to public participation. Computer World in Duluth and Circuit City in Burnsville and Maplewood made a significant contribution to the number of people who participated in the demonstration and the total volume of products collected.

Vintage study.

A vintage study of televisions collected during the project indicated that nearly half of them were manufactured prior to 1980. From a management perspective, it is important to know the ages of electronic products because this information can assist planning for EoL strategies for used TVs, including the availability of secondary market options and costs.

Vintage of televisions, by decade



Plastics recycling.

Plastics from the study met specification standards required for use in the manufacture of new products. To do so economically, large volumes of these plastics must be collected and processed to meet manufacturing production schedules that typically require a monthly minimum of 100,000 pounds.

Test Results for Recovered Flame Retardant HIPS(including comparisons with select virgin resins)

Resin	Melt Flow Rate[1] (200/5.0) (g/10 min)	Notched Izod Impact Strength[2] (ftlb/in)	Tensile Strength[3] (psi)	Density (g/cm^3)
HIPS	7.5	1.5	3100	1.15
Dow Styron 6515	7.5	2.8	2800	1.16
BASF ES 8120	6	2	3500	1.15
Huntsman PS 351	6.5	1.7	4000	1.16

Test results for post-consumer HIPS for melt flow rate, impact strength, tensile strength and density, as evaluated by MBA Polymers, Inc. Plastic sample was from products collected during the Minnesota demonstration project.

[1]This is a measure of how easy it is for the molten plastic to flow at a given temperature (200 degrees Celsius in this case) under a given load (5.0 kg in this case).

[2]This is a measure of how much energy is required to break the material. The plastic is notched to ensure that breaking energy is concentrated on one location on the specimen.

[3] Tensile strength is the greater of tensile strength at yield, which refers to the stress beyond which a material will irrevocably deform or the tensile strength at break, which refers to the stress on a material just prior to breaking.

Recommendations

Encourage participation by industry.

- Voluntary participation by industry will foster private sector recycling opportunities for used electronic products.
- Manufacturers should consider the full life cycle of a product, from design through end-of-life management strategies, to achieve environmentally and economically sustainable products and manufacturing processes.
- Private sector participation in developing reuse and recycling strategies may offer alternatives to government mandates emerging in Europe and elsewhere.

Refine collection procedures.

- Fully define roles and responsibilities for all event sponsors prior to commencing with work.
- Six steps will help retail stores interested in collecting used electronic products from consumers for the purpose of reuse and recycling:
  1. Define a business purpose and communicate with employees about the effort and why the store is involved.
  2. Clearly communicate to customers and participants the purpose of the program and how one can participate.
  3. Describe what will be done with the used products that are collected.
  4. Display appropriate and visible signage at the store before and during the collection events.
  5. Plan for good promotion of collection event.
  6. Staff adequately for the collection event, enlisting store personnel, local government staff, recyclers and/or volunteers from local service organizations.

Reduce transportation costs.

Transportation is a critical budget element for any recycling enterprise. In the demonstration project, transportation, packaging supplies and equipment to move used products from the point of collection to the processing facility cost more than anticipated, despite efforts to adequately plan for this phase of the project in advance. Pallets, gaylord boxes and shrink-wrap are expensive to use and

offer limited opportunities for reuse. Nonetheless, packaging is necessary to reduce handling, to maximize hauling capacity and to minimize worker health and safety concerns.

- **Packaging**
  - Future efforts to recycle used electronics must better identify packaging needs in advance.
  - There is an opportunity to develop a new reusable container type to transport used electronics from the point of collection to processing sites.
  - Improved packaging supplies and materials can reduce the cost to handle and transport used electronic products through the recycling chain.
- **Storage**
  - Identify storage opportunities for product to reduce unnecessary transportation expenses.
  - Large trucks employed to move product long distances should not travel with less than 60 percent of full load weight capacity. (The average truck during the demonstration project moved from collection sites to the processing facility at 28 percent capacity. This increased transportation costs for the demonstration project by as much as 60 percent).
  - Barriers that prohibit maximum loads should be addressed at the earliest stages of a temporary or permanent system. Barriers may include inadequate planning, regulation, inadequate storage capacity near the point of collection.

Spur recycling market development.

Manufacturers and others in the manufacturing supply chain can spur recycling market development for CRT glass and engineering plastics by buying more of these secondary materials for new product manufacturing.

- Manufacturers can contribute to recycling market development efforts by experimenting with reclaimed raw materials from EoL electronics in new product.
- Buy recycled. This includes secondary materials for production and new product with recycled content.
- Accomplishing greater procurement will require attention to specification standards and greater communication along the supply chain as well as within corporate structures, from designers, to manufacturing operations, to utilities and maintenance personnel.
- Commercially viable export markets exist for many secondary commodities and presently offer strong competition in the marketplace for EoL electronics and recovered materials including engineering plastics. Regulators, recyclers and manufacturers should consider the potential environmental and economic consequences of shipping used electronics overseas, including any long-term significance. Good public policy will require better information about export markets and international environmental concerns.

Improve processing technologies.

- The collection and processing efficiencies for recycling used electronics, and the resulting costs or revenues, should be evaluated against the efficiencies for other recyclable materials and waste management systems.
- Significant progress has occurred in recent years in mechanical recycling technologies for engineering plastics and CRT glass from EoL electronics. Nonetheless, further development of recycling technologies is necessary to recover higher value from many electronic materials and components.
- Adopt clear, consistent commodity specifications, especially for post-consumer CRT glass and recovered streams of engineering plastics, to assist recovery of these secondary materials. Commodity specifications communicate clearly to recyclers about how to process material and can signal manufacturers that quality assurance will be met.

Examine regulatory barriers.

- Simple, common sense regulations for recycling used electronic products will be welcomed by local government, recyclers and manufacturers alike. They are an important part of developing a viable recycling infrastructure for used electronic products. Such regulations can provide for minimal concerns of government at the same time they simplify regulatory operations for legitimate recyclers of used electronic products.

Educate the public.

- Efforts to educate the public about the hazards associated with improper disposal of used electronics must also provide clear information about what people can do with used products they no longer want.
- The opportunity to reuse older electronic products is time-sensitive, and the longer products are kept or stored, the less likely that they will be reused. Therefore, education about electronic product reuse must encourage consumers to pass products on to new users or intermediaries as soon as the consumer no longer wants or uses the product.

Looking ahead

This *Report on Minnesota's Demonstration Project* describes work conducted in a specific geographic area over a defined period. The partners fully expect that readers will apply the information and data presented to markets and communities outside Minnesota. Therefore, readers will benefit from paying close attention to similarities and differences between their circumstances and the ones described. It is especially worth noting that it is in the nature of markets for commodity values in those markets to fluctuate. The markets available to us in Minnesota in 2000 may or may not exist here or elsewhere in the future.

Finally, the experience of this project is a useful benchmark, but it is not definitive. The partners view this effort as one of many that will be necessary in creating a viable recycling industry for used electronic products. We invite those working in the field to build on our effort from this demonstration project.